NASA-CR-193763

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Final Technical Report

NASA Grant NAG 5 1363

Giant Molecular Cloud Structure: Clumpiness in Monoceros R2

This project addressed the issue of clumpiness in the material comprising a relatively nearby and isolated giant molecular cloud, namely the Monoceros R2 cloud. It is at a distance of approximately 850 parsecs from the earth, and well above the galactic plain, so that it is well suited for study both in molecular lines, and other tracers. We specifically propose to study the infrared emission as mapped by the IRAS bans in order to determine the degree of clumpiness in the structure, and to evaluate how well the molecular material and the dust emission can be correlated.

The major difficulty in this project, and one that was recognized by the referees in the original proposal, was to find an accurate algorithm for determining the dust column density. We developed a novel solution to this problem, based on the Mobius inversion therom developed by Chen (1990, Phys. Rev. Letters, Vol. 64, p. 1193). From this work we were able to derive a method to invert the four measurements of the dust emission, combined with an assumed emissivity law, to obtain the temperature distribution of dust along this line of site, and with it the total dust column density. This work was published by us already (T. Xie, P.F. Goldsmith, and W. Zhou, Ap.J., Letters, Vol. 371, p. L81, 1991). This algorithm should be a significant improvement over previous approaches used to determine the dust column density, because it allows for the almost inevitable dust temperature distribution and fits its form without recourse to a priori assumptions about its form. A second paper which illustrates the use of this approach for determining the total dust mass of a variety of cloud complexes has been submitted to the Astrophysical Journal, and essentially accepted (Xie, Goldsmith, Zhou, and Snell, 1992).

Analysis of determination of dust column densities using our technique and the IRAS (or other) data reveals that it is the lack of long wavelength data that is the first contributor to the uncertainty in the dust column density. This agrees with the conclusions of other investigations, and will at some point be remedied by the availability of data in the 1 mm to 300 micron wavelength range. The second uncertainty is simply the emissivity of the dust itself, which is not easily determined from observations, and for which different theoretical analyses give quite different results. It is not clear how to reduce this uncertainty at the present time, but we can get a feeling for its impact by trying models with different emissivity and different emissivity laws. It appears that it is very easy to obtain a variation in a factor of 3 in the dust column density due to this cause. An additional uncertainty is the gas to dust ratio.

These problems have largely occupied us to date. We are now at the point of actually applying our algorithm to the Monoceros R2 infrared emission. We have the Big Map data in hand, which we processed using our inversion

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algorithm to obtain the dust column density distribution. We have obtained ^{13}CO map from John Bally at AT & T Bell Laboratory. We have obtained a ^{12}CO map with the FCRAO 14m telescope. We the two molecular maps, we can obtain the ^{13}CO opacity, and correct the ^{13}CO integrated emission for this effect. We will then be in a position to compare the molecular distribution with that of the dust, and to determine to what degree clumpiness seen in the molecular data is reflected in the dust emission.

We feel that our work as supported by NASA NAG 5 1363 has been quite successful. In terms of developing an ability to determine the dust column density, we have perhaps even exceeded even our initial expectations. It is the complexity of this problem that has delayed actually dealing with the Monoceros R2 data itself, but we are confident that this will be completed within the next year.